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(54) **Spherical bearing and method of assembly.**

(57) To make a spherical bearing (10), an outer ring (12) is formed with counterbores (20, 22) at the ends thereof, disposed along a common axis (24) and separated by a radially inwardly extending keel portion (26). A polymer liner (16, 18) is inserted into each end of the outer ring (12) into abutment with the keel portion, the polymer liners being preformed with spherically concave inner surfaces (38, 40) conforming to a ball part (14) entrapped therebetween. Portions (48) of the outer ring are then deformed by upset forming over portion (46) of the polymer liners to lock the polymer liners in position. An electrical sensor can be provided for indicating failure of the polymer liners.

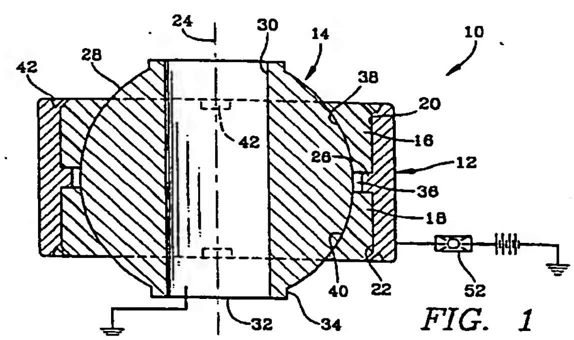

FIG. 1

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This invention relates generally to self-aligning spherical bearings and, more particularly, to heavy duty spherical bearings with solid liners as used, for example, in rod end bearings.

Generally, rod end bearings used in aircraft controls and similar applications require a self-aligning configuration with a solid liner of bronze, brass, polymer, fabric or other bearing material supported by a close fitting steel housing. Snap-together assemblies utilising resilient liners of nylon or similar material result in spherical bearings that do not provide sufficient strength for these demanding applications and do not satisfy the rigorous military specifications.

One method currently used to fabricate heavy duty spherical bearings employs a machined cylindrical sleeve with radially inwardly extending end flanges restricting the end opening of the entrance face. After a liner is manually positioned on the recessed cylindrical surface between the flanges, the sleeve is coined around the ball part of the bearing in a large press, causing the liner to conform, generally, to the shape of the ball part. The bearing is then cured and machined.

Such fabrication requires a long process time, 24 hours or more including the curing step, and often results in an irregular liner which may trap dirt and have non-uniform contact points, affecting performance. The required tedious labour and large press add to the high cost of manufacture. And, due to the distortion caused during coining of the sleeve, the length and diameter of the sleeve must be machined to the sleeve's finished dimensions after assembly of the bearing.

According to the present invention, there is provided a method of making a spherical bearing, the method comprising the steps of:

forming an outer ring with counterbores at the ends thereof, disposed along a common axis and separated by a radially inwardly extending keel portion;

providing a ball part having a spherical diameter less than the inner diameter of the keel portion such that a clearance results between the ball part and the keel portion;

inserting a polymer liner into each end of the outer ring into abutment with the keel portion, the polymer liners having preformed spherically concave inner surfaces conforming to the ball part entrapped therebetween; and

deforming a portion of the outer ring over a portion of the polymer liners to lock the polymer liners in position.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a cross-sectional view illustrating a spherical bearing with a sensing means indicated schematically;

Figure 2 is an end view of a portion of the spherical bearing of Figure 1;

Figure 3 is an enlarged cross-sectional view of a partially formed portion of the outer ring and polymer liner of the spherical bearing of Figure 1, with a portion of the tooling to be applied also shown in cross-section; and

Figure 4 is an enlarged cross-sectional view of the portion of the outer ring and polymer liner of Figure 3 after upset forming.

Referring now to the drawing, Figure 1 illustrates an embodiment as a spherical bearing 10 resulting from the present method of assembly. The spherical bearing 10 comprises an outer ring 12, ball part 14 and polymer liners 16 and 18.

The outer ring 12 is formed with counterbores 20 and 22 at the ends of the outer ring 12 and disposed along common axis 24. The counterbores 20 and 22 are separated by keel portion 26 which extends radially inwardly toward the ball part 14 midway between the ends of the outer ring 12. The keel portion 26 may be a ridge with rectangular cross-section as shown, or may be rounded or of other configuration providing a suitable abutment surface for polymer liners 16 and 18, as described below.

The outer ring 12 may be held in a fixture or housing or may be formed with a shank extending radially with respect to the axis 24, thus making the outer ring 12 an eye member of a rod end or similar device. However, the present invention is not to be limited to rod end bearing applications and may take various forms. The outer ring 12 may be made of mild or stainless steel or other suitable malleable material, by machining or other means.

The ball part 14 has a spherical outer surface 28 and a central bore 30 along the axis 24. The central bore 30 is provided to receive a control rod, mounting fastener or other shaft for self-aligning rotation with respect to the outer ring 12. A ball face 32 may extend axially by means of shoulders 34, as shown, or may be a simple truncation of the spherical outer surface 28 or may be omitted altogether. The ball part 14 may be machined of mild or stainless steel, for example.

The spherical diameter of the ball part 14 along the spherical outer surface 28 is less than the inner diameter of the keel portion 26 such that a clearance 36 results between the ball part 14 and outer ring 12. Thus, the polymer liners 16 and 18 are spaced apart axially by the keel portion 26 and clearance 36. The clearance 36 may be filled with a lubricant and connected with a lubrication channel or reservoir, not shown, to serve as a lubrication groove or may be left open, as illustrated.

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During assembly, the ball part 14 is positioned within the outer ring 12 and the polymer liners 16 and 18 are inserted into the counterbores 20 and 22 from the ends of the outer ring into abutment with the keel portion 26. The polymer liners 16 and 18 are preformed with spherically concave inner surfaces 38 and 40, respectively, which conform to the spherical outer surfaces 28 of the ball part 14 when the liners abut the keel portion 26.

As illustrated in Figure 2, indentations 42 are spaced circumferentially along the end faces of the outer ring 12 and are formed as part of an upset forming technique that deforms portions of the outer ring 12 radially inward over a portion of the polymer liners 16 and 18 while maintaining the initial overall axial length and diameter of the outer ring 12. The indentations 42 may be located near the inside diameter of the outer ring 12, as shown, or may be located nearer the outside diameter thereof while still providing the desired radially inward flow of material.

Preferably, the indentations 42 comprise substantially one-half the circumference of the outer ring 12, the other half of the circumference of the outer ring 12 being distributed in even increments between the indentations 42. In other words, arcuate length "A" of the indentations 42 is approximately equal to arcuate length "B" of the increments between the indentations 42. The preferred number of indentations 42 is between eight and thirty two for a spherical bearing of typical size, the specific number being dependent upon the size of the bearing and the materials used.

As illustrated in Figures 3 and 4, the indentations 42 are formed by discrete tool portions 44 of wedge-shaped tooling. The radially outward surface of the tool portions 44 forms an angle "C" from a line normal to the face of the outer ring 12, and the radially inward surface of the tool portions 44 forms an angle "D" from that line. The same angles are formed with respect to the axis 24 of the outer ring 12, which is parallel to the normal line just described. The term wedge-shaped is intended to include variations with curved surfaces in addition to the single angular shape shown.

As indicated, the tool portions 44 are moved along the normal line into the outer ring 12 such that a portion of the outer ring 12 is deformed and moved radially inwardly over a portion of the polymer liner 16 or 18. Preferably, the polymer liner 16 or 18 is preformed with a bevelled surface 46 and the deformed portion of the outer ring 12 has the form of a first ramp surface 48, which is impressed with angle "D" of the tool portions 44. A preferred angle of the first ramp surface 48 is 45 degrees, as illustrated, the preferred range being between 15 and 60 degrees with respect to the axis 24.

The tool portions 44 also include a stop surface defined by angle "C" which engages a second ramp surface 50 and thereby stabilises the material of the outer ring 12, limiting thinning and radially outward movement of the material. A preferred angle of the ramp surface 50 is 15 degrees, as illustrated; however, a range of zero to approximately 45 degrees may be used with similar effect. As illustrated in Figure 1, the indentations 42 have a rectangular configuration in cross-section when viewed radially, the tool portions 44 being of the same rectangular shape.

The polymer liners 16 and 18 may be formed of various materials, with or without fillers, provided that the material possesses the desired performance requirements, such as temperature stability, low friction and low wear. High performance polymers such as polyetheretherketone (PEEK) and polyamidimide have been found to be suitable. A preferred material is commercially available polyimide with graphite fibres for strength and low friction fillers for lubrication. However, other reinforcement and lubrication fillers, such as for example that known under the Registered Trade Mark "Teflon", may be used.

As illustrated schematically in Figure 1, a sensing circuit may be added to sense electrical conductivity between the outer ring 12 and ball part 14 to indicate wear or failure of the polymer liners 16 and 18. The sensing circuit may include indicator means 52, such as a warning light, alarm, or other device and a power source. Simple electrical connections may be used, depending on the particular application, to provide grounding of the outer ring 12 or ball part 14 and to provide electrical connection of the indicator means 52 to the other of these two elements.

The present invention facilitates more precise initial machining of the outer race because the overall dimensions of the outer race are no longer deformed while encapsulating the liner. Unlike previous methods using liners laid in a recessed cylindrical surface of an outer ring, the disclosed method of assembly allows liners with preformed ball-conforming surfaces to be conveniently inserted axially into the outer ring by machine. The present upset forming technique effectively clinches the liners in position while imparting virtually line for line contact with the ball part, thus improving wear characteristics.

Claims

1. A method of making a spherical bearing (10), the method comprising the steps of:

   forming an outer ring (12) with counterbores (20, 22) at the ends thereof, disposed along a common axis and separated by a

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radially inwardly extending keel portion (26);

providing a ball part (14) having a spherical diameter less than the inner diameter of the keel portion (26) such that a clearance results between the ball part and the keel portion;

inserting a polymer liner (16, 18) into each end of the outer ring into abutment with the keel portion, the polymer liners having preformed spherically concave inner surfaces (38, 40) conforming to the ball part entrapped therebetween; and

deforming a portion (42) of the outer ring over a portion of the polymer liners (16, 18) to lock the polymer liners in position.

2. A method according to claim 1, wherein the polymer liners are preformed with a bevelled outer surface (46) and wherein the deformed portion (48) of the outer ring overlies the bevelled outer surface to lock the polymer liners in position.

3. A method according to claim 1 or 2, wherein the deforming of the outer ring is effected by upset forming, whereby circumferentially spaced material of the outer ring (12) is moved radially inwardly while the overall length and diameter of the outer ring remain substantially unchanged.

4. A method according to claim 3, wherein the upset forming is effected by engagement with discrete portions of wedge-shaped tooling (44) including angled surfaces for moving portions (48) of the outer ring radially inwardly.

5. A method according to claim 4, wherein the angled surfaces of the wedge-shaped tooling (44) form an angle between 15 and 45 degrees with respect to the axis (24) of the outer ring.

6. A method according to claim 4 or 5, wherein the wedge-shaped tooling engages substantially half the circumference of the outer ring, the other half of the circumference being distributed in even increments between the discrete portions of wedge-shaped tooling (44).

7. A method according to claim 6, wherein the number of discrete portions of wedge-shaped tooling (44) is between eight and thirty two.

8. A method according to any one of the preceding claims, wherein the polymer liners (16, 18) include a filler material for reducing friction between the ball part (14) and the polymer liners.

9. A method according to any one of the preceding claims, wherein the polymer liners (16, 18) include a filler material for providing reinforcement.

10. A method according to any one of the preceding claims, further comprising the step of connecting sensing means to the outer ring and the ball portion such that electrical conductivity between the outer ring and the ball portion is sensed to indicate wear or failure of the polymer liners.

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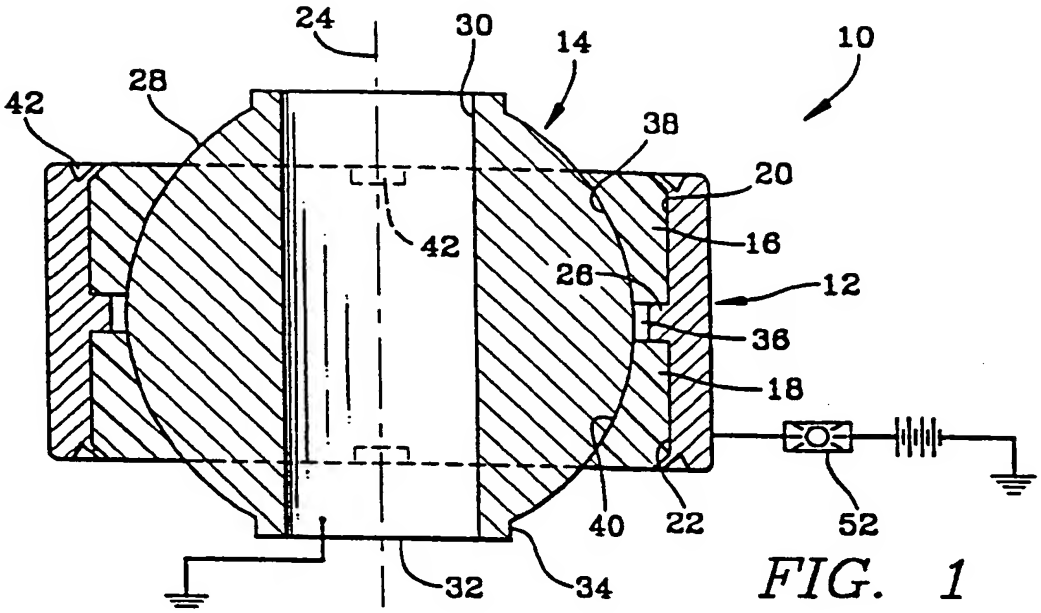

FIG. 1

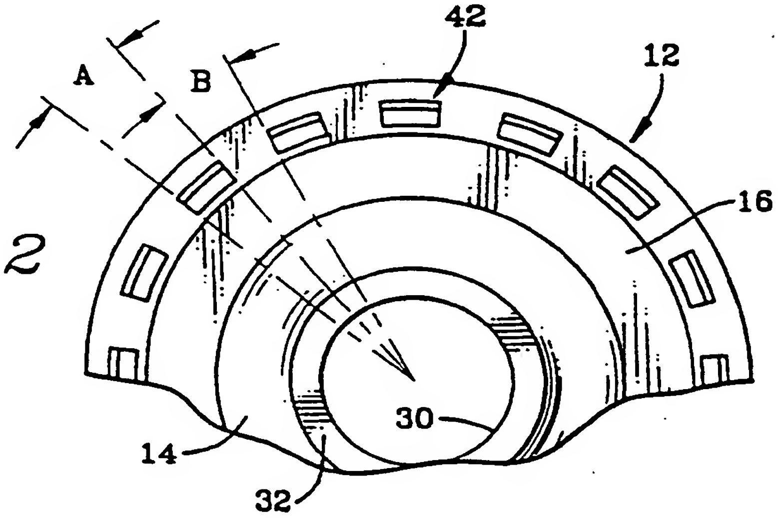

FIG. 2

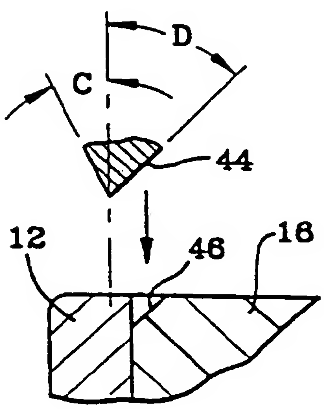

FIG. 3

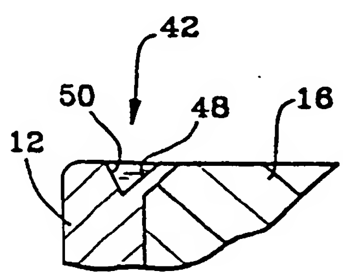

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 94 30 4361

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	FR-A-1 329 437 (FAFNIR) * the whole document * ---	1-3	F16C11/06 F16C43/02
A	US-A-3 801 395 (STUCK) * the whole document * ---	1	
A	US-A-4 003 666 (GAINES) * the whole document * ---	1	
A	US-A-3 700 295 (BUTZOW) * the whole document * ---	1	
A	DE-U-91 14 279 (VALMET HYDRO) * the whole document * ---	8,9	
A	DE-A-19 05 067 (SKF) ---		
A	GB-A-568 117 (SIMMONDS) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F16C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	1 September 1994	Orthlieb, C

CATEGORY OF CITED DOCUMENTS

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